

**WHAT IS CLAIMED IS:**

1. A microcontroller-based system for detecting ground-fault and grounded-neutral conditions in an electrical power distribution system having line and neutral conductors, comprising

- 5       • a sensor producing an output signal responsive to current flow in both the line and neutral conductors of the electrical power distribution system,
- a circuit interrupter for interrupting current flow in said power distribution system in response to a trip signal,
- a microcontroller receiving said sensor output signal and initiating the generation
- 10       of a trip signal upon detection of a ground-fault or a grounded-neutral condition in said power distribution system, said microcontroller being programmed to
- use said sensor output signal to detect ground-fault conditions during spaced time intervals, and
- use said sensor output signal to detect grounded-neutral conditions during
- 15       intervening time intervals between said spaced interval.

2. The system of claim 1 wherein said microcontroller is programmed to detect ground-fault conditions by comparing the magnitude of said sensor output signal with a predetermined ground-fault threshold value.

20 3. The system of claim 1 wherein said microcontroller is programmed to detect grounded-neutral conditions by using said sensor output signal to estimate the impedance of the neutral-to-ground connection in said power distribution system.

25 4. The system of claim 3 wherein said sensor includes a resonant circuit, and said microcontroller is programmed to initiate a ping signal in each of said intervening intervals to produce a damped oscillation in said sensor output signal.

30 5. The system of claim 4 wherein said microcontroller is programmed to estimate the slope of the leading or tail edge of the half cycles of said damped oscillation by measuring two or more points, within a preselected time interval following the initiation of said ping signal, to determine said grounded-neutral condition.

6. The system of claim 4 wherein said microcontroller is programmed to calculate the slope of M half cycles of said damped oscillation within a preselected time interval following the initiation of said ping signal, and to use said slope to determine said grounded-neutral condition.

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7. The system of claim 4 wherein said microcontroller is programmed to compare the peak amplitude of a M half cycles of said damped oscillation with a preselected grounded-neutral threshold value, for each cycle of said damped oscillation within a preselected time interval following the initiation of said ping signal to determine said grounded-neutral condition.

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8. The system of claim 4 wherein said microcontroller is programmed to monitor a plurality of half cycles and use the number of half cycles above a preselected threshold, within a preselected time interval following the initiation of said ping signal, to determine said grounded-neutral condition.

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9. The system of claim 4 wherein said microcontroller is programmed to determine a grounded neutral condition based on a decay factor of a damped oscillation, within a preselected time interval following the initiation of said ping signal, in the presence of a grounded neutral condition.

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10. The system of claim 9 and further where said decay factor is determined by observing a tangential function of an envelope of the peak amplitudes of said damped oscillation.

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11. The system of claim 9 and further where said decay factor is determined by calculating a second order estimate of an envelope of the peak amplitudes of said damped oscillation.

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12. The system of claim 9 and further where said decay factor is determined by calculating a slope of a linear fit of the peak amplitudes of said damped oscillation.

13. The system of claim 9 and further where said decay factor is determined by calculating an estimate of the area below the signal waveform peaks of said damped oscillation.

5 14. The system of claim 1 wherein said sensor has a single transformer for sensing current in both said line and neutral conductors.

15. A microcontroller-based system for detecting ground-fault and grounded-neutral conditions in an electrical power distribution system having line and neutral conductors,  
10 comprising

- a sensor, containing a single current transformer producing an output signal responsive to current flow in both the line and neutral conductors of the electrical power distribution system,
- a microcontroller receiving said sensor output signal and initiating the generation  
15 of a trip signal upon detection of said ground-fault or said grounded-neutral condition in said power distribution system, said microcontroller being programmed to
  - use said sensor output signal to detect ground-fault conditions during spaced time intervals, and
  - 20 • use said sensor output signal to detect grounded-neutral conditions during intervening time intervals between said spaced time intervals, and
  - a circuit interrupter for interrupting current flow in said power distribution system in response to said trip signal.

25 16. A method of detecting ground-fault and grounded-neutral conditions in an electrical power distribution system having both line and neutral conductors, comprising

- producing a signal responsive to current flow in both the line and neutral conductors of the electrical power distribution system,
- 30 • supplying said signal to a microcontroller that is programmed to
- use said signal to detect ground-fault conditions during spaced time intervals,

- use said signal to detect grounded-neutral conditions during intervening time intervals between said spaced intervals,
- initiate the generation of a trip signal upon detection of a ground-fault or a grounded-neutral condition, and
- 5   • interrupting current flow in said power distribution system in response to said trip signal.

17.   The method of claim 16 wherein ground-fault conditions are detected by comparing the magnitude of said signal with a predetermined threshold value.

10   18.   The method of claim 16 wherein grounded-neutral conditions are detected by using said signal to estimate the resistance of the neutral-to-ground connection in said power distribution system.

15   19.   The method of claim 18 wherein said signal is produced by a resonant circuit, and said microcontroller initiates a ping signal in each of said intervening time intervals to produce a damped oscillation in said signal, and compares said damped oscillation with a reference value to determine whether a grounded-neutral condition has occurred.

20   20.   The method of claim 19 wherein said microcontroller compares the peak amplitude of said damped oscillation with a preselected grounded-neutral threshold value, for each cycle of said damped oscillation within a preselected time interval following the initiation of said ping signal.

25   21.   The system of claim 16 wherein current in both said line and neutral conductors is sensed with a single transformer.

22.   A method of detecting ground-fault and grounded-neutral conditions in an electrical power distribution system having both line and neutral conductors and a sensor  
30   circuit producing a signal responsive to current flow in both the line and neutral conductors of the electrical power distribution system, comprising

- using a real-time clock to produce spaced time intervals,
- sampling said signal at said spaced time intervals,

- using the signal sample from each spaced time interval to detect a ground-fault condition, and setting a ground-fault indicator in response to the detection of a ground-fault condition,
- using said signal sample to detect a neutral-to-ground fault condition, and setting  
5 a neutral-to-ground fault indicator in response to the detection of a neutral-to-ground fault condition,
- initiating the generation of a trip signal in response to the setting of a ground-fault or a neutral-to-ground indicator, and
- interrupting current flow in said power distribution system in response to said trip  
10 signal.

23. The method of claim 22 wherein said signal sample is used to detect a ground-fault condition by monitoring the lowest voltage of a negative voltage cycle, and setting said ground-fault indicator if said lowest voltage falls below a predetermined high  
15 threshold value.

24. The method of claim 22 wherein said signal sample is used to verify a ground-fault condition by monitoring the lowest voltage of a negative voltage cycle, and resetting the ground-fault indicator if said lowest voltage is higher than a predetermined low  
20 threshold value.

25. The method of claim 22 wherein said signal sample is used to initiate a ping signal to induce a resonant voltage oscillation in said sensor circuit if said signal sample is of zero or greater voltage.

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26. The method of claim 25 wherein said signal sample is used to determine the presence of a neutral-to-ground condition by monitoring the rate of decay of said induced resonant oscillation in said sensor circuit, and setting said neutral-to-ground fault indicator if said rate of decay is in excess of a predetermined neutral-to-ground threshold  
30 value.